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Multiscale rheological properties of the crust investigated via multiplatform data and evaluated via numerical modelling

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The knowledge of the brittle [U+2044] ductile (B/D) transition inside the crust and upper mantle may provide insights to verify the roles that some hypothesized mechanism, such as slab pull, crustal delamination and the onset of volcanic processes, might have played in the evolution of a tectonically active region. Several recent studies demonstrate that the nature and geometry of the B/D transition produces a significantly impact at spatial scale (i.e. geometry and dimension of regional structures and locally the dimension and location of volcanic and geothermal manifestations). As consequence, the quantitative picture of the B/D transition represents a key point in the understanding of the processes that controls the evolution of several geodynamic environments.

In this study, we present two case studies through a spatial multiscale approach. At regional scale, we analyze the Southern Apennine zone (Italy), for which we computed, starting from the thermal, seismological and geological information, an imaging of the B/D transition along a WSW–ENE-oriented cross-section running from Apulia foreland to Neapolitan Volcanic Zone. The achieved model show that the area is characterized by lateral rheological variations, with two horizons interlayered with ductile horizons, which are quite predominant with respect to vertical ones. The horizontal stratification of lithospheric rheology represents an important geodynamic component and it comprehension could provide new insights on the tectonic processes which played a main role on the Southern Apennine belt formation. The Results suggested that well-constrained rheological models, built integrating information from both relocated earthquakes and thermal state, could give important hints on the mechanical behaviour of the crust and its related tectonic processes.

At local scale, we investigate the effects of B/D transition on the evolution of Neapolitan Volcanic zone. More specifically, we firstly investigate the thermal proprieties and mechanical heterogeneities of the crust beneath the caldera; then we developed a 3D conductive thermal model solving the Fourier equation. We calibrated the model through physical and geometrical parameters: the heat production within the magma chamber and its size. In particular, the optimization procedure has been performed using a methodology based on a Nelder-Mead method, aimed at minimizing the differences between model data and experimental measurements. The achieved thermal field allowed us to determine the rheological stratification of the crust beneath caldera. The computed 3D imaging of B/D transition agreed well with the distribution of earthquake hypocenters.

Finally, the rheological model could be taken into account, as first order of approximation, to better understand the mechanical behaviour that governed the active deformation process in thermal anomalous regions as the case of calderas environments. In this scenario, the knowledge of the rheological state of its volcanic structural system is crucial factor to interpret its dynamic, hence to forecast the future activity of the volcano and to improve the evaluation of the seismic hazard associated to the volcanic activity.